JC10 Rec'd PCT/PTO 17 JAN 2002

Practitioner's Docket No. 297-010818-US(PAR)

CHAPTER II

10/031533

Preliminary Classification:

Proposed Class:

Subclass:

NOTE: "All applicants are requested to include a preliminary classification on newly filed patent applications. The preliminary classification, preferably class and subclass designations, should be identified in the upper right-hand corner of the letter of transmittal accompanying the application papers, for example 'Proposed Class 2, subclass 129.'" M.P.E.P., § 601, 7th ed.

TRANSMITTAL LETTER TO THE UNITED STATES ELECTED OFFICE (EO/US) (ENTRY INTO U.S. NATIONAL PHASE UNDER CHAPTER II)

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/FI00/00652	18 July 2000	19 July 1999

TITLE OF INVENTION

Resonator Structure And A Filter Having Such A Resonator Structure

APPLICANT(S)

Jyrki KAITILA, Markku Ylilammi, Juha ELLA

Box PCT
Assistant Commissioner for Patents
Washington D.C. 20231
ATTENTION: EO/US

CERTIFICATION UNDER 37 C.F.R. §§ 1.8(a) and 1.10*

(When using Express Mail, the Express Mail label number is mandatory; Express Mail certification is optional.)

I hereby certify that, on the date shown below, this correspondence is being:

MAILING

☒ deposited with the United States Postal Service in an envelope addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231

37 C.F.R. § 1.8(a)

☐ with sufficient postage as first class mail.

37 C.F.R. § 1.10 *

☒ as "Express Mail Post Office to Addressee"

Mailing Label No. EL627511463US **(mandatory)**

TRANSMISSION

☐ facsimile transmitted to the Patent and Trademark Office, (703) ________-________.

Shauna Murphy

Signature

Date: January 17, 2002

Shauna Murphy

(type or print name of person certifying)

** Only the date of filing (§ 1.6) will be the date used in a patent term adjustment calculation, although the date on any certificate of mailing or transmission under § 1.8 continues to be taken into account in determining timeliness. See § 1.703(f). Consider "Express Mail Post Office to Addressee" (§ 1.10) or facsimile transmission (§ 1.6(d)) for the reply to be accorded the earliest possible filing date for patent term adjustment calculations.*

NOTE: To avoid abandonment of the application, the applicant shall furnish to the USPTO, not later than 20 months from the priority date: (1) a copy of the international application, unless it has been previously communicated by the International Bureau or unless it was originally filed in the USPTO; and (2) the basic national fee (see 37 C.F.R. § 1.492(a)). The 30-month time limit may not be extended. 37 C.F.R. § 1.495.

WARNING: *Where the items are those which can be submitted to complete the entry of the international application into the national phase are subsequent to 30 months from the priority date the application is still considered to be in the international state and if mailing procedures are utilized to obtain a date the express mail procedure of 37 C.F.R. § 1.10 must be used (since international application papers are not covered by an ordinary certificate of mailing—See 37 C.F.R. § 1.8.*

NOTE: Documents and fees must be clearly identified as a submission to enter the national state under 35 U.S.C. § 371 otherwise the submission will be considered as being made under 35 U.S.C. § 111. 37 C.F.R. § 1.494(f).

I. Applicant herewith submits to the United States Elected Office (EO/US) the following items under 35 U.S.C. § 371:

a. ☒ This express request to immediately begin national examination procedures (35 U.S.C. § 371(f)).

b. ☒ The U.S. National Fee (35 U.S.C. § 371(c)(1)) and other fees (37 C.F.R. § 1.492) as indicated below:

2. Fees

CLAIMS FEE	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
☐*	TOTAL CLAIMS 11	11 −20=	0	× $18.00=	$ 0
	INDEPENDENT CLAIMS 2	2 −3=	0	× $84.00 =	0
	MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+$ 280.00 =	
BASIC FEE**	☐ U.S. PTO WAS INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where an International preliminary examination fee as set forth in § 1.482 has been paid on the international application to the U.S. PTO: ☐ and the international preliminary examination report states that the criteria of novelty, inventive step (non-obviousness) and industrial activity, as defined in PCT Article 33(1) to (4) have been satisfied for all the claims presented in the application entering the national stage (37 C.F.R. § 1.492(a)(4)) .... $100.00 ☐ and the above requirements are not met (37 C.F.R. § 1.492(a)(1)) ....$ 710.00 ☒ U.S. PTO WAS NOT INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where no international preliminary examination fee as set forth in § 1.482 has been paid to the U.S. PTO, and payment of an international search fee as set forth in § 1.445(a)(2) to the U.S. PTO: ☒ has been paid (37 C.F.R. § 1.492(a)(2)) ....$ 740.00 ☐ has not been paid (37 C.F.R. § 1.492(a)(3)) ..$1,040.00 ☐ where a search report on the international application has been prepared by the European Patent Office or the Japanese Patent Office (37 C.F.R. § 1.492(a)(5)) .... $ 890.00				740.00
	Total of above Calculations				= 740.00
SMALL ENTITY	Reduction by 1/2 for filing by small entity, if applicable. Assertion must be made. (note 37 C.F.R. § 1.27)				–
	Subtotal				740.00
	Total National Fee				$ 740.00
	Fee for recording the enclosed assignment document $40.00 (37 C.F.R. § 1.21(h)). (See Item 13 below). See attached "ASSIGNMENT COVER SHEET".				
TOTAL	Total Fees enclosed				$ 740.00

*See attached Preliminary Amendment Reducing the Number of Claims.

☒ Attached is a ☒ check ☐ money order in the amount of $ 740.00

☐ Authorization is hereby made to charge the amount of $ ______

☒ to Deposit Account No. 16-1350

☐ to Credit card as shown on the attached credit card information authorization form PTO-2038.

WARNING: *Credit card information should **not** be included on this form as it may become public.*

☒ Charge any additional fees required by this paper or credit any overpayment in the manner authorized above.

A duplicate of this paper is attached.

WARNING: *"To avoid abandonment of the application the applicant shall furnish to the United States Patent and Trademark Office not later than the expiration of 30 months from the priority date: * * * (2) the basic national fee (see § 1.492(a)). The 30-month time limit may not be extended." 37 C.F.R. § 1.495(b).*

WARNING: *If the translation of the international application and/or the oath or declaration have not been submitted by the applicant within thirty (30) months from the priority date, such requirements may be met within a time period set by the Office. 37 C.F.R. § 1.495(b)(2). The payment of the surcharge set forth in § 1.492(e) is required as a condition for accepting the oath or declaration later than thirty (30) months after the priority date. The payment of the processing fee set forth in § 1.492(f) is required for acceptance of an English translation later than thirty (30) months after the priority date. Failure to comply with these requirements will result in abandonment of the application. The provisions of § 1.136 apply to the period which is set. Notice of Jan. 3, 1993, 1147 O.G. 29 to 40.*

☐ **Assertion of Small Entity Status**

☐ **Applicant hereby asserts status as a small entity under 37 C.F.R. § 1.27.**

NOTE: 37 C.F.R. § 1.27(c) deals with the assertion of small entity status, whether by a written specific declaration thereof or by payment as a small entity of the basic filing fee or the fee for the entry into the national phase as states:

"(c) Assertion of small entity status. Any party (person, small business concern or nonprofit organization) should make a determination, pursuant to paragraph (f) of this section, of entitlement to be accorded small entity status based on the definitions set forth in paragraph (a) of this section, and must, in order to establish small entity status for the purpose of paying small entity fees, actually make an assertion of entitlement to small entity status, in the manner set forth in paragraphs (c)(1) or (c)(3) of this section, in the application or patent in which such small entity fees are to be paid.

(1) Assertion by writing. Small entity status may be established by a written assertion of entitlement to small entity status. A written assertion must:

(i) Be clearly identifiable;

(ii) Be signed (see paragraph (c)(2) of this section); and

(iii) Convey the concept of entitlement to small entity status, such as by stating that applicant is a small entity, or that small entity status is entitled to be asserted for the application or patent. While no specific words or wording are required to assert small entity status, the intent to assert small entity status must be clearly indicated in order to comply with the assertion requirement.

(2) Parties who can sign and file the written assertion. The written assertion can be signed by:

(i) One of the parties identified in §§ 1.33(b) (e.g., an attorney or agent registered with the Office), §§ 3.73(b) of this chapter notwithstanding, who can also file the written assertion;

(ii) At least one of the individuals identified as an inventor (even though a §§ 1.63 executed oath or declaration has not been submitted), notwithstanding §§ 1.33(b)(4), who can also file the written assertion pursuant to the exception under §§ 1.33(b) of this part; or

(iii) An assignee of an undivided part interest, notwithstanding §§ 1.33(b)(3) and 3.73(b) of this chapter, but the partial assignee cannot file the assertion without resort to a party identified under §§ 1.33(b) of this part.

(3) Assertion by payment of the small entity basic filing or basic national fee. The payment, by any party, of the exact amount of one of the small entity basic filing fees set forth in §§ 1.16(a), (f), (g), (h), or (k), or one of the small entity basic national fees set forth in §§ 1.492(a)(1), (a)(2), (a)(3), (a)(4), or (a)(5), will be treated as a written assertion of entitlement to small entity status even if the type of basic filing or basic national fee is inadvertently selected in error.

(i) If the Office accords small entity status based on payment of a small entity basic filing or basic national fee under paragraph (c)(3) of this section that is not applicable to that application, any balance of the small entity fee that is applicable to that application will be due along with the appropriate surcharge set forth in §§ 1.16(e), or §§ 1.16(l).

(ii) The payment of any small entity fee other than those set forth in paragraph (c)(3) of this section (whether in the exact fee amount or not) will not be treated as a written assertion of entitlement to small entity status and will not be sufficient to establish small entity status in an application or a patent."

3. ☒ A copy of the International application as filed (35 U.S.C. § 371(c)(2)):

NOTE: Section 1.495 (b) was amended to require that the basic national fee and a copy of the international application must be filed with the Office by 30 months from the priority date to avoid abandonment. "The International Bureau normally provides the copy of the international application to the Office in accordance with PCT Article 20. At the same time, the International Bureau notifies applicant of the communication to the Office. In accordance with PCT Rule 47.1, that notice shall be accepted by all designated offices as conclusive evidence that the communication has duly taken place. Thus, if the applicant desires to enter the national stage, the applicant normally need only check to be sure the notice from the International Bureau has been received and then pay the basic national fee by 30 months from the priority date." Notice of Jan. 7, 1993, 1147 O.G. 29 to 40, at 35-36. See item 14c below.

a. ☒ is transmitted herewith.

b. ☐ is not required, as the application was filed with the United States Receiving Office.

c. ☐ has been transmitted

i. ☐ by the International Bureau.

Date of mailing of the application (from form PCT/1B/308):

________________.

ii. ☐ by applicant on ________________. *(Date)*

4. ☒ A translation of the International application into the English language (35 U.S.C. § 371(c)(2)):

a. ☐ is transmitted herewith.

b. ☒ is not required as the application was filed in English.

c. ☐ was previously transmitted by applicant on __________. *(Date)*

d. ☐ will follow.

5. ☒ Amendments to the claims of the International application under PCT Article 19 (35 U.S.C. § 371(c)(3)):

NOTE: The Notice of January 7, 1993 points out that 37 C.F.R. § 1.495(a) was amended to clarify the existing and continuing practice that PCT Article 19 amendments must be submitted by 30 months from the priority date and this deadline may not be extended. The Notice further advises that: "The failure to do so will not result in loss of the subject matter of the PCT Article 19 amendments. Applicant may submit that subject matter in a preliminary amendment filed under section 1.121. In many cases, filing an amendment under section 1.121 is preferable since grammatical or idiomatic errors may be corrected." 1147 O.G. 29-40, at 36.

a. ☐ are transmitted herewith.

b. ☐ have been transmitted

i. ☐ by the International Bureau.

Date of mailing of the amendment (from form PCT/1B/308):

________________.

ii. ☐ by applicant on _______________. *(Date)*

c. ☒ have not been transmitted as

i. ☒ applicant chose not to make amendments under PCT Article 19. Date of mailing of Search Report (from form PCT/ISA/210.):

11/29/00.

ii. ☐ the time limit for the submission of amendments has not yet expired. The amendments or a statement that amendments have not been made will be transmitted before the expiration of the time limit under PCT Rule 46.1.

6. ☒ A translation of the amendments to the claims under PCT Article 19 (38 U.S.C. § 371(c)(3)):

a. ☐ is transmitted herewith.

b. ☐ is not required as the amendments were made in the English language.

c. ☒ has not been transmitted for reasons indicated at point 5(c) above.

7. ☒ A copy of the international examination report (PCT/IPEA/409)

☒ is transmitted herewith.

☐ is not required as the application was filed with the United States Receiving Office.

8. ☒ Annex(es) to the international preliminary examination report

a. ☒ is/are transmitted herewith.

b. ☐ is/are not required as the application was filed with the United States Receiving Office.

9. ☒ A translation of the annexes to the international preliminary examination report

a. ☐ is transmitted herewith.

b. ☒ is not required as the annexes are in the English language.

10. ☒ An oath or declaration of the inventor (35 U.S.C. § 371(c)(4)) complying with 35 U.S.C. § 115

a. ☐ was previously submitted by applicant on ________________. *(Date)*

b. ☐ is submitted herewith, and such oath or declaration

i. ☐ is attached to the application.

ii. ☐ identifies the application and any amendments under PCT Article 19 that were transmitted as stated in points 3(b) or 3(c) and 5(b); and states that they were reviewed by the inventor as required by 37 C.F.R. § 1.70.

c. ☒ will follow.

II. Other document(s) or information included:

11. ☒ An International Search Report (PCT/ISA/210) or Declaration under PCT Article 17(2)(a):

a. ☒ is transmitted herewith.

b. ☐ has been transmitted by the International Bureau.

Date of mailing (from form PCT/IB/308): ________________.

c. ☐ is not required, as the application was searched by the United States International Searching Authority.

d. ☐ will be transmitted promptly upon request.

e. ☐ has been submitted by applicant on ________________. *(Date)*

12. ☒ An Information Disclosure Statement under 37 C.F.R. §§ 1.97 and 1.98:

a. ☒ is transmitted herewith.

Also transmitted herewith is/are:

☒ Form PTO-1449 (PTO/SB/08A and 08B).

☒ Copies of citations listed.

b. ☐ will be transmitted within THREE MONTHS of the date of submission of requirements under 35 U.S.C. § 371(c).

c. ☐ was previously submitted by applicant on ________________. *(Date)*

13. ☐ An assignment document is transmitted herewith for recording.

A separate ☐ "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or ☐ FORM PTO 1595 is also attached.

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10/031533

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14. ☒ Additional documents:

a. ☒ Copy of request (PCT/RO/101)

b. ☒ International Publication No. WO 01/06646 A1

i. ☒ Specification, claims and drawing

ii. ☐ Front page only

c. ☒ Preliminary amendment (37 C.F.R. § 1.121)

d. ☒ Other

PCT/IPEA/401; PCT/IPEA/408; Response to Written Opinion; Letter regarding International Applications Merger, Finnish Search Report.PCT Search Report citations

15. ☒ The above checked items are being transmitted

a. ☒ before 30 months from any claimed priority date.

b. ☐ after 30 months.

16. ☐ Certain requirements under 35 U.S.C. § 371 were previously submitted by the applicant on ____________, namely:

AUTHORIZATION TO CHARGE ADDITIONAL FEES

WARNING: *Accurately count claims, especially multiple dependant claims, to avoid unexpected high charges if extra claims are authorized.*

NOTE: "A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 C.F.R. § 1.136(a)(3).

NOTE: "Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. § 1.26(a).

☒ Please charge, in the manner authorized above, the following additional fees that may be required by this paper and during the entire pendency of this application:

☒ 37 C.F.R. § 1.492(a)(1), (2), (3), and (4) (filing fees)

WARNING: *Because failure to pay the national fee within 30 months without extension (37 C.F.R. § 1.495(b)(2)) results in abandonment of the application, it would be best to always check the above box.*

☒ 37 C.F.R. § 1.492(b), (c) and (d) (presentation of extra claims)

NOTE: Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 C.F.R. § 1.492(d)), it might be best not to authorize the PTO to charge additional claim fees, except possible when dealing with amendments after final action.

☒ 37 C.F.R. § 1.17 (application processing fees)

☒ 37 C.F.R. § 1.17(a)(1)–(5) (extension fees pursuant to § 1.136(a).

☐ 37 C.F.R. § 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. § 1.311(b))

NOTE: Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 C.F.R. § 1.311(b).

NOTE: 37 C.F.R. § 1.28(b) requires "Notification of any change in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying . . . issue fee." From the wording of 37 C.F.R. § 1.28(b): (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

☒ 37 C.F.R. § 1.492(e) and (f) (surcharge fees for filing the declaration and/or filing an English translation of an International Application later than 30 months after the priority date).

SIGNATURE OF PRACTITIONER

Reg. No.: 24,622

Clarence A. Green

(type or print name of practitioner)

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PERMAN & GREEN, LLP

P.O. Address

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425 Post Road, Fairfield, CT 06430 USA

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Express Mail No.: EL627511463US
Applicant(s): KAITILA et al.
INTERNATIONAL APPLICATION NO.: PCT/FI00/00652
INTERNATIONAL FILING DATE: 7/18/00
TITLE: RESONATOR STRUCTURE AND A FILTER HAVING SUCH A RESONATOR STRUCTURE
ATTORNEY DOCKET NO.: 297-010818-US(PAR)

Box PCT
Commissioner of Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Dear Sir:

Please amend the above-identified, patent application as follows:

IN THE SPECIFICATION:

After the Title and before the first paragraph, please insert the following new paragraph:

--(New) This application claims the benefit of the earlier filed International Application No. PCT/FI00/00652, International Filing Date, July 18, 2000, which designated the United States of America, and which international application was published under PCT Article 21(2) in English as WO Publication No. WO 01/06646 A1.--

The Commissioner is hereby authorized to charge payment for any additional fees associated with this communication or credit any over payment to Deposit Account No. 16-1350.

Respectfully submitted,

17 feb 02

Date

Clarence A. Green Reg. No.: 24,622
PERMAN & GREEN, LLP
425 Post Road, Fairfield, CT 06430
(203) 259-1800
Customer No.: 2512

4|PRTS

10/031533 PCT/FI00/00655
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Resonator structure and a filter having such a resonator structure

The invention relates in general to piezoelectric resonators and filters comprising piezoelectrical resonators. In particular, the invention relates to a resonator structure having a simple structure and good electrical response at the operation frequency.

The development of mobile telecommunications continues towards ever smaller and increasingly complicated handheld units. The development leads to increasing requirements on the miniaturization of the components and structures used in the mobile communication means. This development concerns radio frequency (RF) filter structures as well, which despite the increasing miniaturization should be able to withstand considerable power levels, have very steep passband edges, and low losses.

The RF filters used in prior art mobile phones are often discrete surface acoustic wave (SAW) filters or ceramic filters. Bulk acoustic wave (BAW) resonators are not yet in widespread use, but they have some advantages compared to SAW resonators. For example, BAW structures have a better tolerance of high power levels.

It is known to construct thin film bulk acoustic wave resonators on semiconductor wafers, such as silicon (Si) or gallium arsenide (GaAs) wafers. For example, in an article entitled "Acoustic Bulk Wave Composite Resonators", Applied Physics Letters, Vol. 38, No. 3, pp. 125-127, Feb. 1, 1981, by K.M. Lakin and J.S. Wang, an acoustic bulk wave resonator is disclosed which comprises a thin film piezoelectric layer of zinc oxide (ZnO) sputtered over a thin membrane of silicon (Si). Further, in an article entitled "An Air-Gap Type Piezoelectric Composite Thin Film Resonator", I5 Proc. 39th Annual Symp. Freq. Control, pp. 361-366, 1985, by Hiroaki Satoh, Yasuo Ebata, Hitoshi Suzuki, and Choji Narahara, a bulk acoustic wave resonator having a bridge structure is disclosed.

Figure 1 shows one example of a bulk acoustic wave resonator having a bridge structure. The structure comprises a membrane 130 deposited on a substrate 200. The resonator further comprises a bottom electrode 110 on the membrane, a piezoelectric layer 100, and a top electrode 120. A gap 210 is created between the membrane and the substrate by etching away some of the substrate from the top side. The gap serves as an acoustic isolator, essentially isolating the vibrating resonator structure from the substrate.

In the following, certain types of BAW resonators are first described.

Bulk acoustic wave resonators are typically fabricated on silicon (Si), gallium arsenide (GaAs), glass, or ceramic substrates. One further ceramic substrate type used is alumina. The BAW devices are typically manufactured using various thin film manufacturing techniques, such as for example sputtering, vacuum evaporation or chemical vapor deposition. BAW devices utilize a piezoelectric thin film layer for generating the acoustic bulk waves. The resonance frequencies of typical BAW devices range from 0.5 GHz to 5 GHz, depending on the size and materials of the device. BAW resonators exhibit the typical series and parallel resonances of crystal resonators. The resonance frequencies are determined mainly by the material of the resonator and the dimensions of the layers of the resonator.

A typical BAW resonator consists of three basic elements:
- an acoustically active piezoelectric layer,
- electrodes on opposite sides of the piezoelectric layer, and
- acoustical isolation from the substrate.

The piezoelectric layer may be for example, ZnO, AlN, ZnS or any other piezoelectric material that can be fabricated as a thin film. As a further example, also ferroelectric ceramics can be used as the piezoelectric material. For example, $PbTiO_3$ and $Pb(Zr_xTi_{1-x})O_3$ and other members of the so called lead lanthanum zirconate titanate family can be used.

The material used to form the electrode layers is an electrically conductive material. The electrodes may be comprised of for example any suitable metal, such as tungsten (W), aluminum (Al), copper (Cu), molybdenum (Mo), nickel (Ni), titanium (Ti), niobium (Nb), silver (Ag), gold (Au), and tantalum (Ta). The substrate is typically composed of for example Si, SiO_2, GaAs, glass, or ceramic materials.

The acoustical isolation can be produced with for example the following techniques:
- with a substrate via-hole,
- with a micromechanical bridge structure, or
- with an acoustic mirror structure.

In the via-hole and bridge structures, the acoustically reflecting surfaces are the air interfaces below and above the devices. The bridge structure is typically manufactured using a sacrificial layer, which is etched away to produce a free-standing structure. Use of a sacrificial layer makes it possible to use a wide variety of substrate materials, since the substrate does not need to be modified very much, as in

the via-hole structure. A bridge structure can also be produced using an etch pit structure, in which case a pit has to be etched in the substrate or the material layer below the BAW resonator in order to produce the free standing bridge structure.

Figure 2 illustrates one example of various ways of producing a bridge structure. Before the deposition of other layers of the BAW structure, a sacrificial layer 135 is deposited and patterned first. The rest of the BAW structure is deposited and patterned partly on top of the sacrificial layer 135. After the rest of the BAW structure is completed, the sacrificial layer 135 is etched away. Figure 3 shows also the substrate 200, a membrane layer 130, the bottom electrode 110, the piezoelectric layer 100, and the top electrode 120. The sacrificial layer can be realized using for example ceramic, metallic or polymeric material.

In the via-hole structure, the resonator is acoustically isolated from the substrate by etching away the substrate from under a major portion of the BAW resonator structure. Figure 3 shows a via-hole structure of a BAW resonator. Figure 4 shows the substrate 200, a membrane layer 130, the bottom electrode 110, the piezoelectric layer 100, and the top electrode 120. A via-hole 211 has been etched through the whole substrate. Due to the etching required, via-hole structures are commonly realized only with Si or GaAs substrates.

A further way to isolate a BAW resonator from the substrate is by using an acoustical mirror structure. The acoustical mirror structure performs the isolation by reflecting the acoustic wave back to the resonator structure. An acoustical mirror typically comprises several layers having a thickness of one quarter wavelength at the center frequency, alternating layers having differing acoustical impedances. The number of layers in an acoustic mirror is typically ranging from three to nine. The ratio of acoustic impedance of two consecutive layers should be large in order to present as low acoustic impedance as possible to the BAW resonator, instead of the relatively high impedance of the substrate material. In the case of a piezoelectric layer that is one quarter of the wavelength thick, the mirror layers are chosen so that as high acoustic impedance as possible is presented to the resonator. This is disclosed in US patent 5 373 268. The material of the high impedance layers can be for example gold (Au), molybdenum (Mo), or tungsten (W), and the material of the low impedance layers can be for example silicon (Si), polysilicon (poly-Si), silicon dioxide (SiO_2), aluminum (Al), or a polymer. Since in structures utilizing an acoustical mirror structure, the resonator is isolated from the substrate and the substrate is not modified very much, a wide variety of materials can be used as a substrate. The polymer layer may be comprised of any polymer material having a low loss charac-

teristic and a low acoustic impedance. Preferably, the polymer material is such that it can withstand temperatures of at least 350 °C, since relatively high temperatures may be needed during deposition of other layers of the acoustical mirror structure and other structures. The polymer layer may be comprised of, by example, polyimide, cyclotene, a carbon-based material, a silicon-based material or any other suitable material.

Figure 4 shows an example of a BAW resonator on top of an acoustical mirror structure. Figure 4 shows the substrate 200, the bottom electrode 110, the piezoelectric layer 100, and the top electrode 120. The acoustical mirror structure 150 comprises in this example three layers 150a, 150b. Two of the layers 150a are formed of a first material, and the third layer 150b in between the two layers is formed from a second material. The first and second materials have different acoustical impedances as described previously. The order of the materials can be varied. For example, the material with a high acoustical impedance can be in the middle and the material with a low acoustical impedance on both sides of the middle material, or vice versa. The bottom electrode may also be used as one layer of the acoustical mirror.

Figure 5 shows a further example of a BAW resonator structure. The BAW resonator illustrated in Figure 5 is a stacked resonator structure having two piezoelectric layers 100. In addition to the bottom 110 and top 120 electrodes, a stacked structure requires a middle electrode 115, which is connected to ground potential. Figure 6 further shows the membrane layer 130, the substrate 200 and the etch pit 210 isolating the structure from the substrate.

The cut-off frequency for a resonator is determined by assuming that the crystal resonator is infinite in the lateral direction. It is thus determined directly by the material of the layers in the resonator structure and by the thickness of the layers. The cut-off frequency is the mechanical resonance frequency of a laterally infinite plate.

The lateral dimensions of the resonator (or any plate) cause lateral resonance modes to emerge, and the basic resonance frequency of a resonator or that of a finite plate is somewhat higher or lower than its cut-off frequency. This fundamental lateral resonance mode or, in other words, the first mode lateral resonance corresponds to a situation, where there is an amplitude maximum in the middle of the resonator area.

In a finite plate there can be various mechanical vibrations, and any lateral resonance modes can be excited mechanically. Certain lateral resonance modes may be

excited piezoelectrically, when an alternating voltage is exerted over the crystal. These lateral resonance modes that are usually at different frequencies cause the surface of the resonator to oscillate. The piezoelectrically excited strongest resonance mode is called the main mode and the other piezoelectrically excited modes are called spurious resonance modes. The spurious resonance modes usually occur at somewhat lower and/or higher frequencies than the cut-off frequency of a resonator.

One of the desired properties of a filter is that at the frequencies which the filter passes, the response of the filter is as even as possible. The variations in the frequency response are called the ripple. The frequency response of a filter should thus be constant, for example in a bandpass filter, over the bandwidth of the filter. In the blocking frequencies the ripple is usually not a problem.

The problem with the spurious resonance modes of crystal resonators and, for example, BAW resonators is that the ripple in filters that are constructed using these resonators is at least partly caused by spurious resonance modes of the resonators. This is discussed, for example, in an article entitled "Thin film bulk acoustic wave filters for GPS", in 1992 Ultrasonic Symposium, pp. 471-476, by K. M. Lakin, G. R. Kline and K. T. McCarron. The spurious resonance modes deteriorate the properties of systems that comprise crystal resonators or BAW resonators. The ripple in a frequency response of a filter is one example of the effect of the spurious resonances.

An object of the invention is to provide a resonator structure. A further object is to provide a resonator structure having good electrical response. A further object of the invention is to provide a resonator structure that is easy to manufacture.

Objects of the invention are achieved by dampening the piezoelectrically excited wave near the edge of the piezoelectrically excitable area.

A resonator structure according to the invention is a resonator structure comprising two conductor layers and a piezoelectric layer in between the conductor layers, said conductor layers and piezoelectric layer extending over a first area of the resonator structure, which first area is a piezoelectrically excitable area of the resonator structure, and it is characterized in that

- the resonator structure is arranged to have a zone, which confines a center area within the first area of the resonator, and

- the layer structure in the zone is arranged to be such that piezoelectrically excited vibrations are dampened more effectively in the zone than in the center area.

A filter according to the invention is a filter comprising at least one resonator structure, which comprises two conductor layers and a piezoelectric layer in between the conductor layers, said conductor layers and piezoelectric layer extending over a first area of the resonator structure, which first area is a piezoelectrically excitable area of the resonator structure, and it is characterized in that
- the resonator structure is arranged to have a zone, which confines a center area, within the first area of the resonator, and
- the layer structure in the zone is arranged to be such that piezoelectrically excited vibrations are dampened more effectively in the zone than in the center area.

A resonator structure according to the invention comprises two conductive layers and a piezoelectric layer between the conductive layers. The conductive layers form the electrodes of the resonator. The piezoelectric layer may be a piezoelectric crystal or it may be a thin-film layer of piezoelectric material.

An electrically excitable area of a resonator refers here to the area to which all the electrode layers and the piezoelectric layer(s) of the resonator extend. In a resonator structure according to the invention, there is a dampening zone that encircles a certain part of the electrically excitable area of the resonator. Term center area refers here to this part of the electrically excitable area, which is inside the dampening zone. The center area does not have to be, for example, in the center of the resonator area. The dampening zone may be partly or wholly inside the piezoelectrically excitable area or it may be just outside the piezoelectrically excitable area. In the last option to piezoelectrically excitable area forms the center area, in the other options a certain part of the piezoelectrically excitable area forms the center area.

Dampening at the edge of the piezoelectrically excitable area suppresses higher order lateral frequency modes, which are related to the spurious resonances. A relatively larger part of the wave of higher order lateral resonance modes than of the first order lateral resonance mode is confined to the edge of the piezoelectrically excitable area. Therefore modification of the properties of the edge of the piezoelectrically excitable area affects more the higher order lateral resonance modes.

A zone that attenuates vibration better than a center area it confines can be constructed, for example, by having a dampening layer, which has an opening within the piezoelectrically excitable area of the resonator. The opening defines the center

area of the resonator. The dampening layer may be, for example, a frame-like layer; in such a frame-like layer the opening in the dampening layer, which defines the center area, is quite large compared to the total area of the dampening layer. The dampening layer may be, for example, a layer of lossy material, and it may be located as any layer of the layer structure. It may be, for example, on top of the top electrode, below the bottom electrode or between the piezoelectric layer and an electrode.

The shape of the piezoelectrically excitable area of the resonator or that of the center area (for example, the shape of the opening in a dampening layer) is not restricted to any particular shape in a resonator structure according to the invention. For example, rectangular, oval or circular center areas are possible, as well as any other shapes. The width of the dampening zone need not be uniform. Typically the opening in the dampening layer has similar shape than the piezoelectrically excitable area of the resonator, but the size of the opening a somewhat smaller than that of the piezoelectrically excitable area.

The resonator structure according to the invention enhances the properties of conventional crystal resonators and especially the properties of thin-film BAW resonators. The properties of the prior-art BAW resonator types, for example of BAW those resonator types discussed above, can be enhanced by modifying the structures according to the invention. Further, when the properties of the resonators are enhanced, the properties of the components that comprise resonators are improved. Specifically, it is advantageous to manufacture filter using the resonator structures according to the invention. Such filters may be used, for example, in mobile communication devices.

The invention will now be described more in detail with reference to the preferred embodiments by the way of example and to the accompanying drawings where

Figure 1 illustrates a bulk acoustic wave resonator according to prior art,

Figure 2 shows another bulk acoustic wave resonator structure having a bridge structure,

Figure 3 illustrates a bulk acoustic wave resonator having a via-hole structure,

Figure 4 illustrates a bulk acoustic wave resonator isolated from the substrate by an acoustic mirror structure,

Figure 5 illustrates a stacked bulk acoustic wave resonator,

Figure 6 illustrates schematically a cross-section of an exemplary resonator structure according to a first preferred embodiment of the invention and a cross-section of a corresponding prior-art resonator structure,

Figure 7 shows a calculated response of a resonator structure according to the preferred embodiment of the invention on Smith's chart, and

Figure 8 shows schematically cross-sections of exemplary resonator structures according to a second and third preferred embodiments of the invention.

Above in conjunction with the description of the prior art reference was made to Figures 1-5. The same reference numerals are used for corresponding parts in the figures.

The dampening effect can be demonstrated by studying the resonance modes of two resonator structures 600 and 601. The cross-sections of the resonator structures 600 and 601 are presented in Fig. 6. The 220 μm wide piezoelectrically excitable area of the resonator structures 600 and 601 is the thicker area (marked with reference numbers 603, 604 in resonator structure 600) in the middle of the resonator structures 600 and 601. The resonator structure 600 is an example of a resonator structure according to a first preferred embodiment of the invention, and it comprises a 10 μm wide dampening frame-like zone 603 at the edge of the piezoelectrically excitable area, within the piezoelectrically excitable area. The center area 604 of the resonator structure 601 according to a first preferred embodiment of the invention is also presented in Figure 6.

The resonance frequencies of the structures are calculated, for example using FEM.

When the resonance frequencies are calculated, the different acoustical dampening at the various regions of the structure can be taken into account by using a quality factor Q. The quality factor can be defined separately for each region. A large quality factor refers to small energy losses (losses are caused by the transformation of vibrational energy to heat), and small Q factor refers to large energy losses. The resonator structure 600 is studied by assuming that the quality factor Q has value 1000 in the regions where there is no additional damping (i.e. region 602 and center area 604), and $Q = 50$ in the 10 μm wide zone 603 at the edge of the piezoelectrically excitable area. These values of Q have no special meaning, they merely express the difference in the assumed damping properties at the various regions of the

resonator structure. The cut-off frequencies relating to the piezoelectrically excited wave in the various regions is illustrated as thickness in the vertical direction in Fig. 6. The cut-off frequency in region 603 is the same as that in the region 604, i.e. the dampening frame-like zone simulated here differs from the center area only by its stronger attenuation properties.

Once the mechanical resonance modes are calculated and the piezoelectric effect is taken into account (either directly in the calculation or using different techniques), it is possible to present the behavior of the resonator structures using a Smith's chart. Fig. 7 presents the results of two simulations on a Smith's chart. When calculating Smith's chart in Fig. 7, the impedance of the BAW resonators has been compared to a typical 50 Ω impedance. In Smith's chart, frequency increases in a clockwise manner. A resonator which resonates only in the basic resonance mode produces a circle on Smith's chart. Possible loops in the diagram indicate spurious resonance frequencies.

The solid line 701 in Figure 7 represents the response of the state-of-the-art, prior-art BAW resonator where there is no dampening zone around a center area, and the loops indicating spurious resonance modes can be clearly seen. The dashed line 702 presents the response of the resonator structure where there is a frame-like dampening zone. The dashed line resembles a circle and there are no loops. The loops have been suppressed to slight dents.

The dashed line in the Smith's chart indicates that a frame-like zone around the piezoelectrically excitable area enhances the performance of a resonator structure. The dashed line is somewhat closer to the center of the chart than the solid lines. This means that also the basic resonance mode is slightly dampened, but the dampening is not very strong.

The dampening zone can be constructed, for example, by depositing a layer of a lossy film, which layer has an opening defining the center area within the piezoelectrically excitable area, in the resonator structure. The lossy film may be, for example, polymer film. In this simulation the dampening zone around the center area of the resonator has only different attenuation properties than the rest of the piezoelectrically excitable area. If a thick dampening layer, which has an opening within the piezoelectrically excitable area, overlaps an otherwise practically uniform piezoelectrically excitable area, the cut-off frequency relating to a piezoelectrically excitable wave is typically different in the center area than in edge of the piezoelectrically

excitable area, where the dampening zone is present. This may further enhance the electrical properties of a resonator according to the invention.

Figure 8a presents schematically a cross-section of a resonator structure 800 as an example of a resonator structure according to a second preferred embodiment of the invention. In the resonator structure 800 there is a piezoelectrical layer 100, a bottom electrode 110 and a top electrode 120 on a substrate 200. Possible membrane, gap or mirror structure between the substrate 200 and the bottom electrode 110 are not shown in Figure 8. Furthermore, the resonator structure 800 comprises a frame-like layer 801 of dampening material on top of the top electrode 120. The frame-like layer 801 may be placed, alternatively, somewhere between the electrode layers, for example. The opening 802 in the frame-like layer 801 defines the center area of resonator structure 800. It is possible that a frame-like dampening layer is so wide that it extends over the edges of a top electrode or, in other words, over the edges of the piezoelectrically excitable area of a resonator.

Figure 8b presents schematically a cross-section of a resonator structure 810 according to a third preferred embodiment of the invention. The resonator structure 810 is otherwise similar to the resonator structure 800, but in resonator structure 810 there is, instead of a frame-like dampening layer 801 extending only to the piezoelectrically excitable area, a dampening layer 803 which extends over the edges of the piezoelectric layer 100, covering the exposed piezoelectric material not covered by the top electrode, and which is, for example, between the top electrode 120 and the piezoelectric layer 100. Also in this case the dampening layer 803 has an opening 802 within the piezoelectrically excitable area. The opening 803 defines the center area of resonator structure 810. Some piezoelectric materials require protection from moisture or humidity, and the layer 803 may, for example, in addition to being a damping layer, perform as a protection layer. Conventional passivation layers are typically made of SiO_2 or Si_3N_4, which do not dampen vibrations effectively.

Figure 8c illustrates schematically a cross-section of a resonator structure 820 according to a fourth preferred embodiment of the invention. In resonator structure 820 there is a frame-like layer 804, which encircles the piezoelectrically excitable area without substantially overlapping the piezoelectrically excitable area and which is made of material attenuating vibrations. The center area of this resonator 820 is the piezoelectrically excitable area of the resonator.

BAW resonators presented in Figure 8 may be, for example, resonators having an Au bottom electrode, a ZnO or AlN piezoelectric layer and an Al top electrode. Al-

ternatively, any other suitable materials may be used for the electrodes and piezoelectric layer(s) in resonators according to the invention. For example, materials discussed in connection with prior-art BAW resonators may be used. The dampening layer may be, for example, polyimide. For a BAW resonator having a resonance frequency about 1 GHz, the thickness of an Au bottom electrode is typically 200-500 nm, the thickness of an Al top electrode is typically about 400-600 nm and the thickness of a ZnO piezoelectric layer is about 2 μm. If AlN is used, the thickness of an AlN piezoelectric layer is about 3 μm at 1 GHz. As is well-known in the art, the resonance frequency depends on the thickness and material of all layers in the resonator structure. The thickness of the dampening layer is typically of the same order than that of the top electrode. An appropriate width for the dampening layer or an appropriate shape and size for the opening in the dampening layer can be found, for example, experimentally.

The BAW resonators presented in Figure 8 are, as an example, on membrane 130, below which there is a gap 210 in the substrate 200. Alternatively, a resonator according to the invention may have, for example, a bridge structure, an in-hole structure or an acoustic mirror. It is possible that a resonator according to the invention has more than one piezoelectric layers between the top and bottom electrodes, similarly as presented in Figure 5.

BAW resonators are used here as an example of piezoelectric resonators, where a dampening zone at the edge of the piezoelectrically excitable area enhances the properties of the resonator. The invention is not restricted to BAW resonators, and may be used to enhance the properties of crystal resonators, too.

The expressions indicating directions, such as top and bottom electrodes, refer to the position of an electrode compared to the substrate. A top electrode is on the opposite side of the piezoelectric layer as the substrate, and the bottom electrode is on the same side of the piezoelectric layer as the substrate. These and any other possible expressions indicating directions are used to make the description of the resonator structure more eligible. These expressions do not restrict the resonator structures according to the invention in any way.

Claims

1. A resonator structure (600, 800, 810, 820) comprising two conductor layers (110, 120) and a piezoelectric layer (100) in between the conductor layers, said conductor layers and piezoelectric layer extending over a first area of the resonator structure, which first area is a piezoelectrically excitable area of the resonator structure, **characterized** in that
- the resonator structure is arranged to have a zone (603, 801, 803, 804), which confines a center area (604, 802) within the first area of the resonator, and
- the layer structure in the zone is arranged to be such that piezoelectrically excited vibrations are dampened more effectively in the zone than in the center area.

2. A resonator structure (800, 810, 820) according to claim 1, **characterized** in that the resonator structure further comprises at least one layer (801, 803, 804) of material, which material dampens vibrations effectively and which layer has an opening (802) within the first area.

3. A resonator structure according to claim 2, **characterized** in that the material, which dampens vibrations effectively, is polymeric material.

4. A resonator structure according to claim 3, **characterized** in that the material is polyimide.

5. A resonator structure according to claim 2, **characterized** in that the layer of material, which dampens vibrations effectively, is adjacent to one of the conductor layers.

6. A resonator structure according to claim 5, **characterized** in that the layer of material, which dampens vibrations effectively, is between one of the conductor layers and the piezoelectric layer.

7. A resonator structure (810) according to claim 1, **characterized** in that the layer of material, which dampens vibrations effectively, extends at least over the part of the piezoelectric layer, which is not within the first area.

8. A resonator structure (800) according to claim 1, **characterized** in that the zone (801) is within the first area.

9. A resonator structure (810) according to claim 1, **characterized** in that the zone (803) is at least partly outside the first area.

10. A resonator structure (820) according to claim 1, **characterized** in that the zone (804) substantially confines the first area.

11. A resonator structure according to claim 1, **characterized** in that it further comprises a second piezoelectric layer in between the conductive layers and a conductor layer in between the piezoelectric layers.

12. A filter comprising at least one resonator structure which comprises two conductor layers (110. 120) and a piezoelectric layer (100) in between the conductor layers said conductor layers and piezoelectric layer extending over a first area of the resonator structure, which first area is a piezoelectrically excitable area of the resonator structure, **characterized in that**
- the resonator structure is arranged to have a zone (603, 801, 803), which confines a center area (604, 802) within the first area of the resonator, and
- the layer structure in the zone is arranged to be such that piezoelectrically excited vibrations are dampened more effectively in the zone than in the center area.

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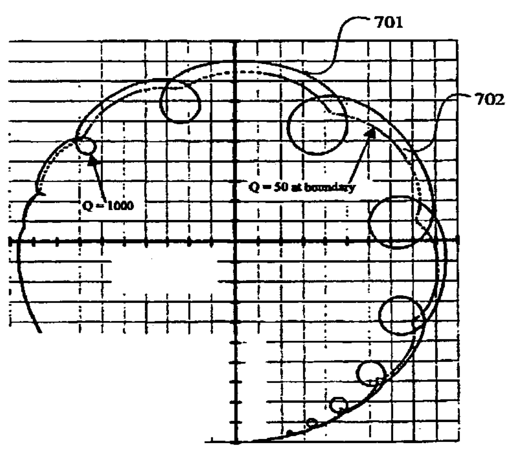
(54) Title: RESONATOR STRUCTURE AND A FILTER HAVING SUCH A RESONATOR STRUCTURE



(57) Abstract: Resonator structure (600, 800, 810, 820) comprises two conductor layers (110, 120) and a piezoelectric layer (100) in between the conductor layers, and said conductor layers and piezoelectric layer extend over a first area of the resonator structure, which first area is a piezoelectrically excitable area of the resonator structure. The resonator structure is characterized in that it is arranged to have a zone (603, 801, 803, 804), which confines a center area (604, 802) within the first area of the resonator, and the layer structure in the zone is arranged to be such that piezoelectrically excited vibrations are dampened more effectively in the zone than in the center area.

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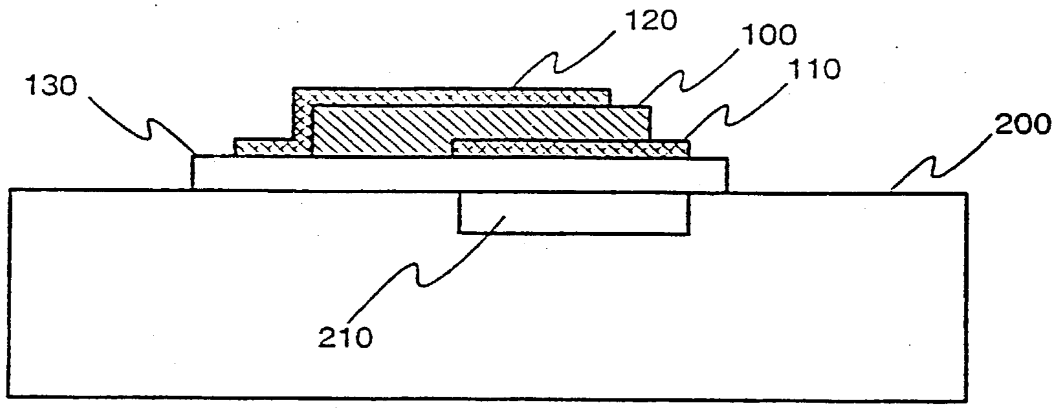

Fig. 1
PRIOR ART

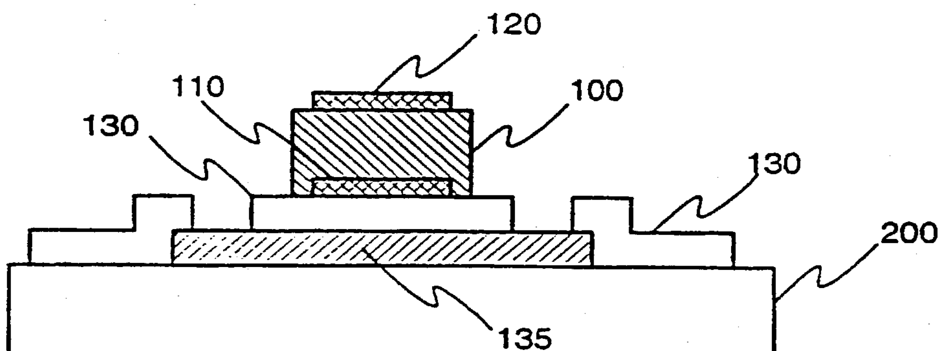

Fig. 2
PRIOR ART

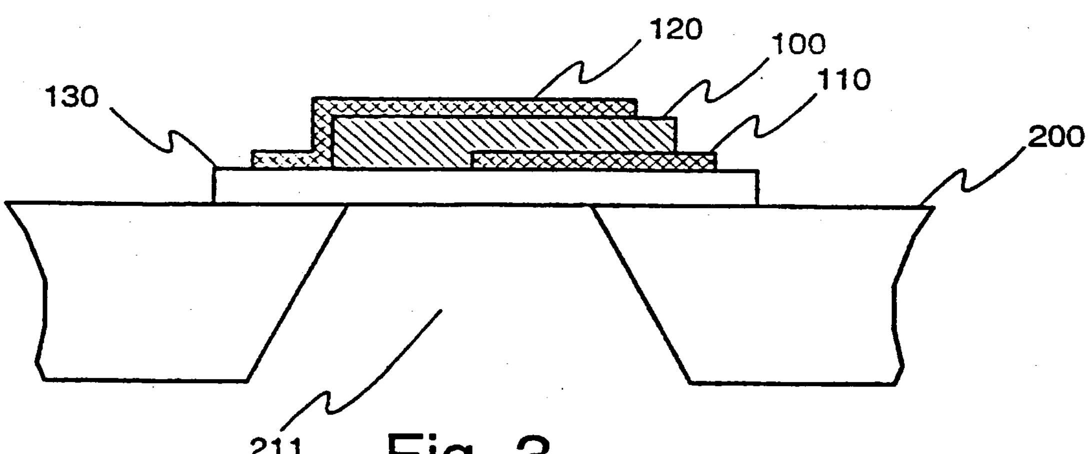

Fig. 3
PRIOR ART

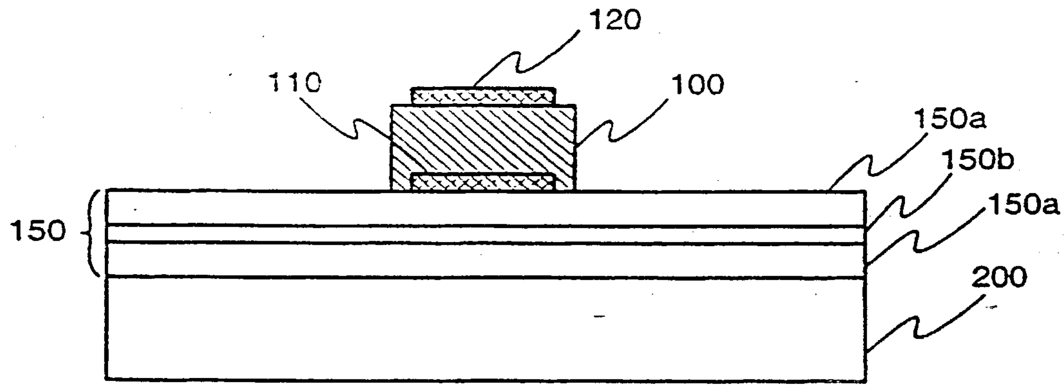

Fig. 4
PRIOR ART

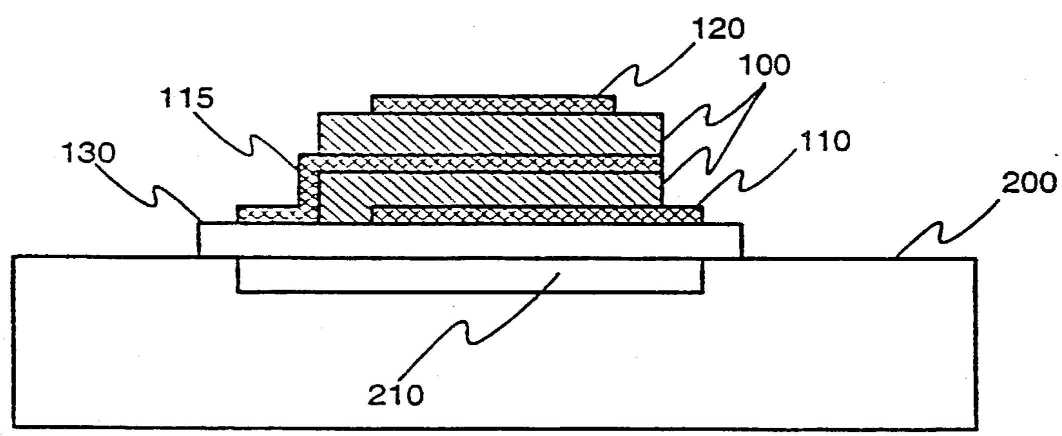

Fig. 5
PRIOR ART

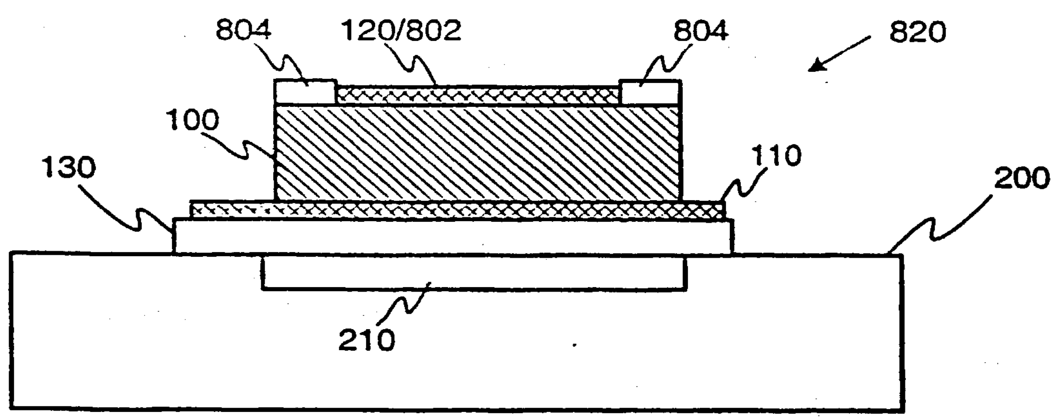

Fig. 8c

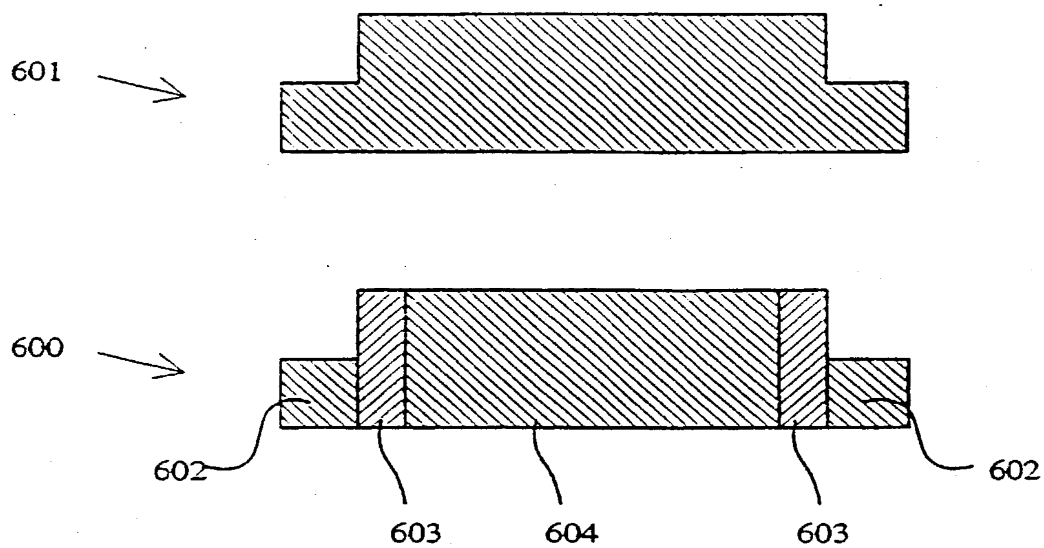

Fig. 6

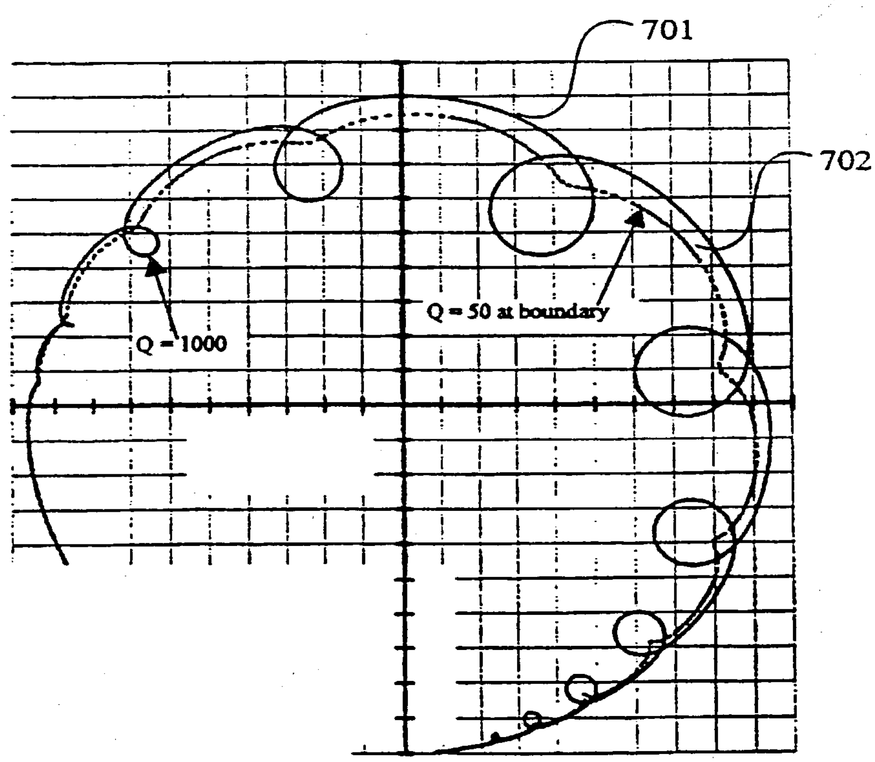

Fig. 7

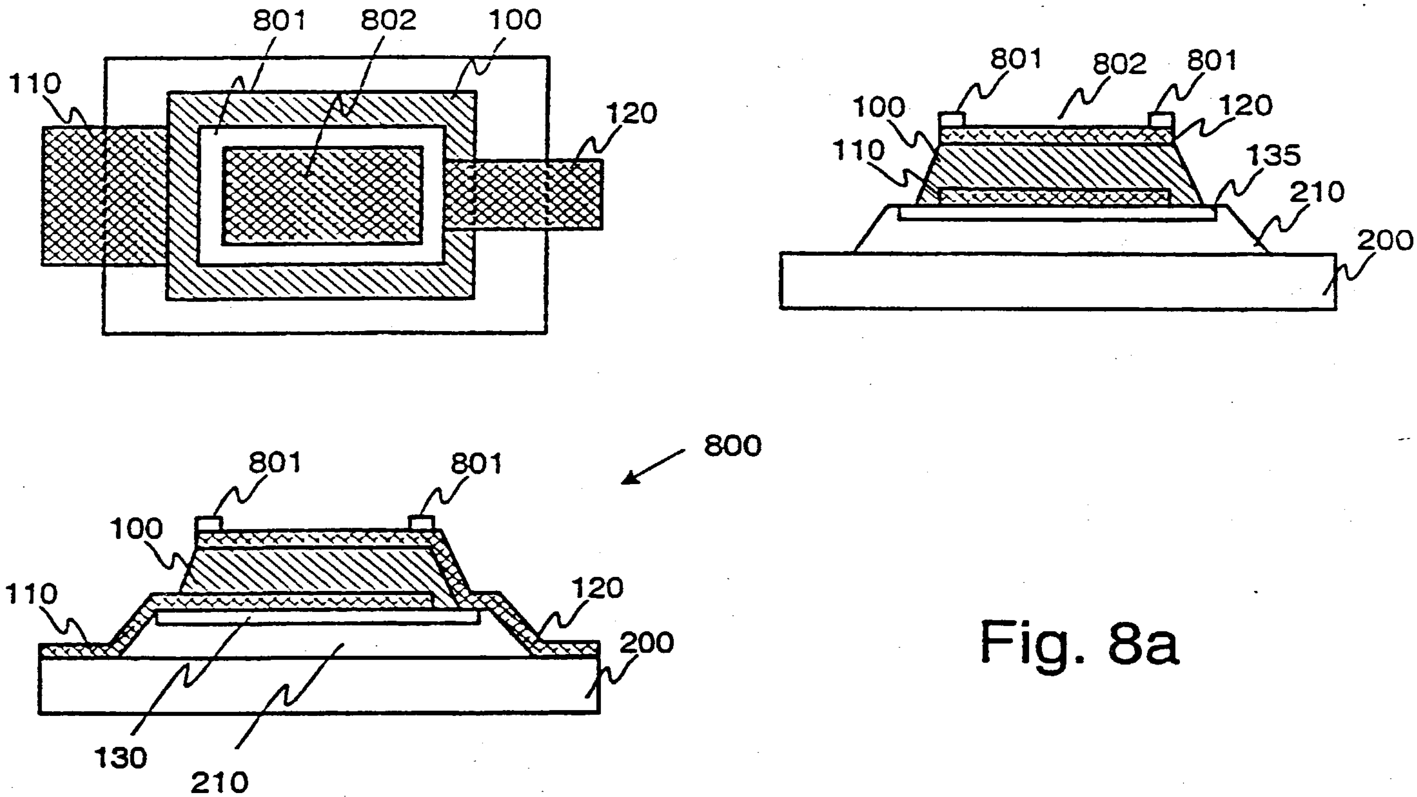
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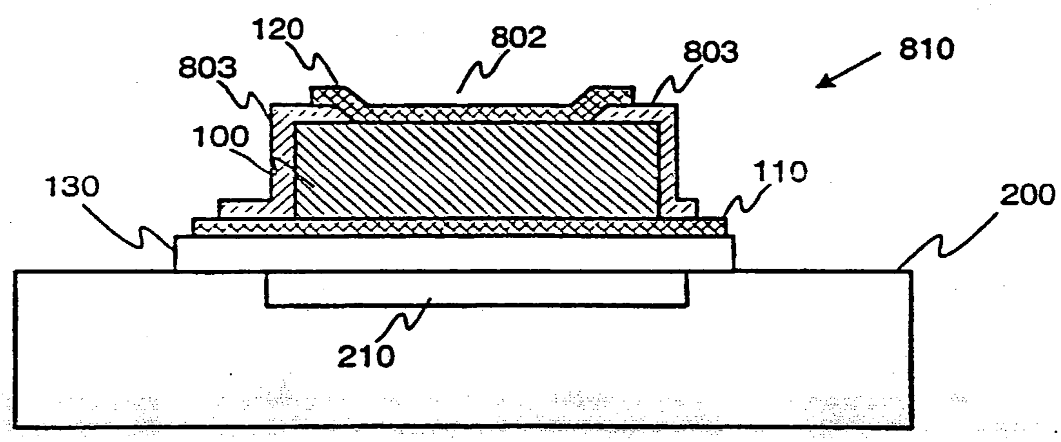
Fig. 8a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810
803
100
110
130
200
210

Fig. 8b

Docket No.: 297-010818-US(PAR)

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Title: **RESONATOR STRUCTURE AND A FILTER HAVING SUCH A RESONATOR STRUCTURE**

the specification of which

(check one)

☐ is attached hereto.

☒ was filed on 18 July 2000 as PCT International Application Number PCT/FI00/00652
and was amended on (if applicable) 5 November 2001

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International Application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

(Number)	(Country)	(Day/Month/Year Filed)	Priority Not Claimed
991619	Finland	19 July 1999	☐
PCT/FI00/00652	PCT	18 July 2000	☐
			☐
			☐

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

(Application Serial No.) (Filing Date)

(Application Serial No.) (Filing Date)

(Application Serial No.: (Filing Date)

I hereby claim the benefit under 35 U.S.C. Section 120 of any United States application(s), or Section 365(c) of any PCT International Application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International Application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C.F.R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

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(patented, pending, abandoned)

(Application Serial No.) (Filing Date) (Status)
(patented, pending, abandoned)

(Application Serial No.) (Filing Date) (Status)
(patented, pending, abandoned)

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100 1533 .041602

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Full name of fifth inventor:	
Fifth inventor's signature:	DATE
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NC 24825 US

Docket No.: 297-010818-US(PAR)

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Title: **RESONATOR STRUCTURE AND A FILTER HAVING SUCH A RESONATOR STRUCTURE**

the specification of which

(check one)

☐ is attached hereto.

☒ was filed on 18 July 2000 as PCT International Application Number PCT/FI00/00652
and was amended on (if applicable) 5 November 2001

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International Application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

(Number)	(Country)	(Day/Month/Year Filed)	Priority Not Claimed
991619	Finland	19 July 1999	☐
PCT/FI00/00652	PCT	18 July 2000	☐
			☐
			☐

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

(Application Serial No.) (Filing Date)

(Application Serial No.) (Filing Date)

(Application Serial No.: (Filing Date)

I hereby claim the benefit under 35 U.S.C. Section 120 of any United States application(s), or Section 365(c) of any PCT International Application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International Application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C.F.R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application Serial No.) (Filing Date) (Status)
(patented, pending, abandoned)

(Application Serial No.) (Filing Date) (Status)
(patented, pending, abandoned)

(Application Serial No.) (Filing Date) (Status)
(patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

10071533 .041602

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (list name and registration number)

All attorneys listed under Customer No.: 2512

Send Correspondence to:

Customer No.: 2512

Direct ~~Telephone Calls~~ to: (name and telephone number)
Clarence A. Green, Reg. No.: 24,622 (203) 259-1800

Full name of sole or first inventor: KAITILA, Jyrki
Sole or first inventor's signature: DATE
Residence: 4. Linja 14 B 45, FIN-00530 Helsinki, Finland
Citizenship: Finnish
Post Office Address: 4. Linja 14 B 45, FIN-00530 Helsinki, Finland

2-00

Full name of second inventor: YLILAMMI, Markku
Second inventor's signature: M. Ylilammi DATE March 17 2002
Residence address: Peräsin 2 A, FIN-02320 Espoo, Finland FIX
Citizenship: Finnish
Post Office Address: Peräsin 2 A, FIN-02320 Espoo, Finland

Full name of third inventor: ELLÄ, Juha
Third Inventor's signature: **DATE**
Residence address: Kääriäisentie 5, FIN-24800 Halikko, Finland
Citizenship: Finnish
Post Office Address: Kääriäisentie 5, FIN-24800-Halikko, Finland

Full name of fourth inventor:
Fourth inventor's signature: **DATE**
Residence address:
Citizenship:
Post Office Address:

Full name of fifth inventor:
Fifth inventor's signature: **DATE**
Residence address:
Citizenship:
Post Office Address:

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NC 24825 US

Docket No.: 297-010818-US(PAR)

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(Application Serial No.) (Filing Date)

(Application Serial No.: (Filing Date)

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(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
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(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Clarence A. Green, Reg. No.: 24,622 (203) 259-1800

Full name of sole or first inventor: **KAITILA, Jyrki**	
Sole or first inventor's signature:	**DATE**
Residence: **4. Linja 14 B 45, FIN-00530 Helsinki, Finland**	
Citizenship: **Finnish**	
Post Office Address: **4. Linja 14 B 45, FIN-00530 Helsinki, Finland**	

Full name of second inventor: **YLILAMMI, Markku**	
Second inventor's signature:	**DATE**
Residence address: **Peräsin 2 A, FIN-02320 Espoo, Finland**	
Citizenship: **Finnish**	
Post Office Address: **Peräsin 2 A, FIN-02320 Espoo, Finland**	

3-00

Full name of third inventor:
ELLÄ, Juha

Third Inventor's signature: DATE
Juha Ellä 11th of March 2002

Residence address:
Kääriäisentie 5, FIN-24800 Halikko, Finland FIX

Citizenship:
Finnish

Post Office Address:
Kääriäisentie 5, FIN-24800-Halikko, Finland

Full name of fourth inventor:

Fourth inventor's signature: DATE

Residence address:

Citizenship:

Post Office Address:

Full name of fifth inventor:

Fifth inventor's signature: DATE

Residence address:

Citizenship:

Post Office Address:

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